(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 970 899 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
22.11.2023 Bulletin 2023/47

(21) Application number: **20306057.9**

(22) Date of filing: **18.09.2020**

(51) International Patent Classification (IPC):
B23K 26/03 (2006.01) ***B23K 26/042*** (2014.01)
B23K 26/0622 (2014.01) ***B23K 26/082*** (2014.01)
B23K 26/352 (2014.01) ***H01L 21/20*** (2006.01)
H01L 21/268 (2006.01) ***H01L 21/324*** (2006.01)
B23K 101/40 (2006.01) *B23K 101/42* (2006.01)

(52) Cooperative Patent Classification (CPC):
B23K 26/032; B23K 26/042; B23K 26/0622; B23K 26/082; B23K 26/352; H01L 21/268;
B23K 2101/40; B23K 2101/42

(54) **METHOD OF AND SYSTEM FOR UNIFORMLY IRRADIATING A FRAME OF A PROCESSED SUBSTRATE HAVING A PLURALITY OF FRAMES**

VERFAHREN UND SYSTEM ZUR GLEICHMÄSSIGEN BESTRAHLUNG EINES RAHMENS EINES VERARBEITETEN, MEHRERE RAHMEN AUFWEISENDEN SUBSTRATS

PROCÉDÉ ET SYSTÈME D'IRRADIATION UNIFORME D'UN CADRE DE SUBSTRAT TRAITÉ AYANT PLUSIEURS CADRES

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(43) Date of publication of application:
23.03.2022 Bulletin 2022/12

(73) Proprietor: **Laser Systems & Solutions of Europe**
92230 Gennevilliers (FR)

(72) Inventors:
- **MAZZAMUTO, Fulvio**
  92230 Gennevilliers (FR)
- **PERROT, Sylvain**
  92230 Gennevilliers (FR)
- **DOURI, Nabil**
  92230 Gennevilliers (FR)
- **THEBAULT, Guillaume Vincent**
  92230 Gennevilliers (FR)
- **HUET, Karim Mikaël**
  92230 Gennevilliers (FR)
- **GONZALEZ TRUJILLO, Guillermo Abraham**
  92230 Gennevilliers (FR)

(74) Representative: **Jacobacci Coralis Harle**
32, rue de l'Arcade
75008 Paris (FR)

(56) References cited:
EP-A2- 0 681 316 **WO-A1-2018/216281**
US-A1- 2002 047 580 **US-A1- 2004 031 779**
US-A1- 2007 024 787

EP 3 970 899 B1

Description

TECHNICAL FIELD OF THE INVENTION

[0001] The invention relates to the irradiation of semiconductor substrates. More precisely the invention relates to a method and a system for uniformly irradiating a frame of a processed substrate according to the preamble of claims 1 and 11 (see for example US 2007/024787 A1).

BACKGROUND INFORMATION AND PRIOR ART

[0002] To manufacture semiconductor devices, a semiconductor substrate is exposed to a pulsed light beam during a process called thermal processing.

[0003] A semiconductor substrate is generally formed by a wafer of material which comprises a plurality of frames. Each frame comprises one or more integrated circuits.

[0004] During the thermal processing, the irradiation of the plurality of frames must follow some specific rules in order to irradiate each frame uniformly. The irradiation must be managed in order to avoid any overlap (corresponding to two or more irradiations of a frame).

[0005] Furthermore, the wafer also has some areas that should not be irradiated. Indeed, the edges of the wafer are fragile and the irradiation could cause damages.

[0006] A first known solution is to use an irradiation that is enough to cover the full wafer at the same time. In such a solution, there is no need to manage transition of irradiation from one frame to another. The uniformity is thus performed thanks to the arrangement of the system.

[0007] In such a system, a protective ring is used in order to prevent the edges from the irradiation.

[0008] However, such system cannot deliver a sufficient energy density to cover the entire wafer at the same time. Furthermore, the irradiation of the protective ring could generate particles that could degrade the wafer.

[0009] A second known solution is based on the use of a smaller irradiation that is not enough to cover the full wafer. This smaller irradiation is combined with a scanning stage adapted to move the wafer below the irradiation so that the full wafer is uniformly exposed without interruption. As an alternative, an optical scanning system can be used to move the irradiation in order to uniformly irradiate the wafer without interruption (the wafer is not moved in this alternative). As another alternative, a system comprising a scanning stage and an optical scanning system is adapted to irradiate uniformly the wafer (with the smaller irradiation).

[0010] However, using a scanning stage is only adapted for slow scanning process as said scanning stage is generally heavy. Furthermore, it is quite difficult to achieve an accurate scanning process with such systems. Finally, the synchronization of the movements of the scanning stage and the optical scanning system is quite complex to control.

SUMMARY OF THE INVENTION

[0011] According to a first aspect of the present invention, a method for uniformly irradiating a frame of a processed substrate, said processed substrate comprising a plurality of frames, two consecutive frames being separated by an intermediate zone, is defined in claim 1, said method comprises at least the following steps of:

- determining an initial position of said processed substrate using a detecting unit,
- comparing said detected initial position with a first predetermined position associated with a first frame of the processed substrate,
- irradiating said first frame of the processed substrate by an irradiation beam emitted by a source unit and scanned by a scanning unit based on the first predetermined position, said irradiation beam being adapted to cover uniformly the whole first frame.

[0012] Thanks to the invention, the irradiation is directed to a frame of the processed substrate. As the localization of the frame is known, the invention enables the precise irradiation of the frame. Furthermore, the irradiation is such that the whole frame is uniformly irradiating leading to a best annealing process of the processed substrate.

[0013] The present invention thus allows the precise irradiation of the parts of the processed substrate that need to be uniformly irradiated (i.e. the frames) and avoids irradiation of the parts that could be damaged by such irradiation (i.e. edges and intermediate zone).

[0014] Other advantageous and non-limiting features of the method according to the invention include:

- the method further comprises a step of moving said processed substrate from said detected initial position to said first predetermined associated with the first frame of the processed substrate;
- the method further comprises a step of moving said scanning unit based on the first predetermined position such that the irradiation beam is directed to the first frame of the processed substrate;
- the scanning unit is configured such that the irradiation beam is attenuated in the intermediate zone to more than 80% compared to the irradiation beam covering the first frame;
- the processed substrate comprising at least one reference mark, said step of determining the initial position comprises a step of detecting said at least one reference mark on the processed substrate;
- the processed substrate comprising edges of a peripheral area and a notch, said step of determining the initial position comprises a step of detecting said edges of the peripheral area and said notch on the

processed substrate;

- the method further comprises steps of:

  - moving the processed substrate from the first predetermined position to a second predetermined position associated with a second frame of the processed substrate, said second frame being directly adjacent to said first frame, and
  - irradiating said second frame of the processed substrate by the irradiation beam emitted by the source unit based on the second predetermined position, said irradiation beam being adapted to cover uniformly the whole second frame;

- the method further comprises steps of:

  - moving said scanning unit based on a second predetermined position associated with a second frame of the processed substrate, said second frame being directly adjacent to said first frame, and
  - irradiating said second frame of the processed substrate by the irradiation beam emitted by the source unit based on the second predetermined position, said irradiation beam being adapted to cover uniformly the whole second frame;

- said step of detecting comprises a step of comparing said detected initial position to at least one edge position; and
- the method also comprises a step of blocking the irradiation of the processed substrate if the initial position corresponds to at least one edge position.

[0015] According to a second aspect of the present invention, a system for uniformly irradiating a frame of a processed substrate, said processed substrate comprising a plurality of frames, two consecutive frames being separated by an intermediate zone, is defined in claim 11, said system comprising at least the following features:

- a support designed to bear said processed substrate,
- a detecting unit configured to determine an initial position of said processed substrate,
- a control unit configured to compare said detected initial position with a first predetermined position associated with a first frame of the processed substrate, and
- an scanning unit configured to irradiate said first frame of the processed substrate by emitting an irradiation beam, said irradiation beam adapted to cover uniformly the whole first frame.

[0016] Other advantageous and non-limiting features of the system according to the invention include:

- the system also comprises a positioning unit configured to move said processed substrate from said detected initial position to a first predetermined position associated with a first frame of the processed substrate;
- the system also comprises an overhead moving unit adapted to move the scanning unit based on the first predetermined position such that the irradiation beam is directed to the first frame of the processed substrate;
- the optical system is configured such that the irradiation beam is attenuated to more than 80% in the intermediate zone compared to the irradiation beam covering the first frame;
- an irradiation wavelength of the irradiation beam is lower than 1064 nanometers, preferably equal to or lower than 355 nanometers;
- the the light source comprises a laser source; and
- the system further comprises a vacuum chamber housing the processed substrate and the support.

[0017] The system and method according to the invention will be described next, in reference with the appended drawings.

[0018] On the appended drawings:

- Figure 1 is a schematic view of an example of a processed substrate;
- Figure 2 is a schematic view of frames supported by the processed substrate of Figure 1;
- Figure 3 represents a first embodiment of a system for uniformly irradiating a frame of the processed substrate according to the invention;
- Figure 4 represents a second embodiment of a system for uniformly irradiating a frame of the processed substrate according to the invention;
- Figure 5 represents a third embodiment of a system for uniformly irradiating a frame of the processed substrate according to the invention;
- Figure 6 represents a fourth embodiment of a system for uniformly irradiating a frame of the processed substrate according to the invention; and
- Figure 7 shows an exemplary flowchart corresponding to a method for uniformly irradiating a frame of the processed substrate according to the invention.

[0019] In the present specification, the expression "uniformly irradiating" a surface means that the conditions of irradiation allow the whole considered surface to be exposed to the same light energy density and exposure duration.

[0020] Figure 1 shows an example of a processed substrate 1. The processed substrate 1 is typically a silicon wafer or a compound wafer, such as commonly used in the semiconductor devices industries.

[0021] As visible in Figures 1 and 2, the processed substrate 1 supports an array of frames 2 on its processed surface 5. Each frame comprises several areas.

Each area of the frame presents specific optical and thermal properties. In other words, each frame comprises active devices, here for example formed by the arrangement of electronic devices such as transistors, resistors and the corresponding metallic interconnects.

[0022] Two successive frames are separated by an intermediate zone 7 (Figures 1 and 2). This intermediate zone 7 is generally free from active devices as it is generally damaged during the manufacturing of semiconductor devices. Preferably, the width of the intermediate zone 7 is lower than 25 micrometers (μm).

[0023] As represented in Figure 1, the processed substrate 1 also comprises a peripheral area 9 situated on its peripheral edge. The peripheral area 9 is too small to support complete active devices.

[0024] Figures 3 to 6 represent different embodiments of a system 20; 21; 22; 23 for irradiating uniformly a frame 2 of the processed substrate 1 (particularly the processed surface 5 of the processed substrate 1).

[0025] In the following, common elements of the different embodiments represented in Figures 3 to 6 are represented, if possible, by the same references and are described in a common way.

[0026] As represented in Figures 3 to 6, the system 20; 21; 22; 23 comprises a source unit 30. This source unit 30 comprises a light source 31 configures to emit a pulsed light beam 100 towards the processed surface 5 of the processed substrate 1.

[0027] The light source 31 is for example an ultraviolet (UV) light source. The light source 31 comprises a laser source. Different types of laser source can be used here. An excimer laser light source can be used here for example. The wavelength of the emitted pulsed light beam 100 is here lower than 1064 nanometers (nm), even lower than 532 nanometers. Preferably, wavelength of the emitted pulsed light beam 100 is equal to or lower than 355 nanometers.

[0028] As shown in Figures 3 to 6, the source unit 30 also comprises an optical system 33 which is coupled to the light source 31. This optical system 33 is suitable for modifying, controlling or monitoring the emitted pulsed light beam 100. As an example, the optical system 33 is suitable for modulating its fluence. The fluence corresponds to the energy delivered by the light source 31 per unit of area of the processed surface 5 of the processed substrate 1. The optical system 33 is positioned on the beam path between the light source 31 and the processed substrate 1. Fluence is preferably rapidly modulated by the optical system 33. The optical system 33 may be for instance an optical modulator suitable for modulating the transmission of the source unit 30. Finally, in other words, the optical system 33 is suitable for modulating the emitted pulsed light beam 100 with a fast response time. As an example, the response time is faster than 500 nanoseconds, preferably faster than 50 nanoseconds. The modulated light beam 101 outputs from the source unit 30.

[0029] The modulated light beam 101 is then directed to a scanning unit 40 (Figures 3 to 6). The scanning unit 40 is configured to irradiate the processed surface 5 of the processed substrate 1.

[0030] As visible in Figures 3 to 6, the scanning unit 40 comprises two mirrors 41, 42. Each mirror is able to be rotated thanks to an associated rotation mechanism 43, 44. The modulated beam 101 is thus reflected by the two mirrors 41, 42 of the scanning unit 40 and outputs a reflected beam 102. The rotation mechanism 43, 44 is suitable for adapting the reflected beam 102 issuing from the two mirrors 41, 42 to the processed substrate 1 and the aimed irradiation of the processed surface 5.

[0031] The scanning unit is for example a standard galvo scanner system. As a variant, the scanning unit can be a polygon scanner system. As another variant, the scanning unit can be a combination of polygons and mirrors.

[0032] The scanning unit 40 also comprises an optical system 47. The optical system 47 is positioned between the two mirrors 41, 42 and the processed substrate 1. In complement to the source unit 30, the optical system 47 is configured to focus the reflected beam 102 on the processed surface 5 of the processed substrate 1. The optical system 47 is for example here a telecentric lens.

[0033] An irradiation beam 105 outputs from the scanning unit 40. In order to obtain a localized irradiation, the irradiation beam 105 has here an irradiation wavelength lower than 1064 nanometers (nm), even lower than 532 nanometers. Preferably, this irradiation wavelength is equal to or lower than 355 nanometers.

[0034] Advantageously, the scanning unit 40 is configured to emit the irradiation beam 105 with an adapted shape and size in order to perform the objectives of the present invention. More particularly, the scanning unit 40 is configured to scan the irradiation beam 105 in order to uniformly irradiate one frame of the processed surface 5 of the processed substrate 1.

[0035] Combined with the scanning unit 40, the optical system 33 is configured such that the irradiation beam 105 is attenuated in transmitted energy in the intermediate region 7 of the processed substrate 1. The irradiation beam is for example attenuated from 0% to more than 80 % in the intermediate zone 7 compared to the irradiated beam covering the frame 2 of the processed substrate 1. The optical system 33 is also configured such that the irradiation beam 105 is for example attenuated from 80% to almost 100% in the adjacent frames.

[0036] The attenuation in the optical system 33 is performed by modifying the transmission of the light beam by different physical means (and the associated physical phenomena). Different examples of physical means can be cited: sound waves that modify the optical properties of the material, electro-absorption modulation and electro-optic system in order to apply a voltage to modify the optical properties of the material or magneto-optic modulation that modifies the light propagation by applying a magnetic field on the material.

[0037] In practice, the attenuation in the optical system

33 is for example performed by an acousto-optic modulator, an electro-absorption modulator, an electro-optic modulator, a magneto-optic modulator or micro and nano electromechanical devices (MEMS and NEMS).

[0038] Considering a Gaussian or a hat profile, the dimensions of the irradiation beam 105 are for example higher than 20 micrometers (μm) in one direction and higher than 20 micrometers in the other direction.

[0039] The processed surface 5 is here irradiated by a micro-spot associated with the irradiation beam 105. In other words, the scanning system 40 is configured to scan the processed substrate 1 with the irradiation beam 105 for example a circular surface of the processed substrate 1 with a diameter wider than 33 millimeters (mm).

[0040] Here, the largest surface irradiated by the irradiation beam 105 corresponds to the surface of the frame 2. The surface of the frame is equal to or smaller than 26x33 mm^2.

[0041] Finally, the scanning unit 40 is configured to emit the irradiation beam 105 with specific parameters: for example, at a given location, the irradiation time is shorter than 30 microseconds (μs), even shorter than 1 microsecond. Preferably, the irradiation beam 105 is shorter than 1 nanosecond.

[0042] As represented in Figures 3 to 6, the system 21; 22; 23; 24 comprises a support 50 designed to bear the processed substrate 1.

[0043] As an alternative represented in Figures 4 and 6, the system 22; 24 comprises a vacuum chamber 70 housing the processed substrate 1 and the support 50. The vacuum chamber 70 is suitable for controlling the environment of irradiation of the processed substrate 1.

[0044] The system 21; 22; 23; 24 also comprises a detecting unit 80. The detecting unit 80 is suitable for determining the position of the processed substrate 1 on the support 50. The detecting unit 80 comprises here a pattern camera and an associated pattern recognizing algorithm suitable for identifying and localizing a reference mark on the processed surface 5 of the processed substrate 1. The reference mark is for example a specific local pattern or a notch 8 formed on the processed surface 5 of the processed substrate 1 (Figure 1).

[0045] The pattern camera is for example based on visible light (wavelength comprised between 400 and 800 nanometers) or on infrared light (wavelength higher than 800 nanometers). The pattern camera based on visible light is preferably used for a reference mark on the processed surface 5 of the processed substrate 1. The pattern camera based on infrared light is for example used for a reference mark on a buried surface or on the opposite surface of the processed surface 5.

[0046] The data from the detecting unit 80 are then used in order to match the position of the to-be-irradiated frame and the irradiation beam 105 (or the corresponding exposure position). Two alternatives are considered in the present invention to perform a movement.

[0047] Figures 3 and 4 represent the first alternative, in which the support (and thus the to-be-irradiated frame of the processed substrate 1) is moved in order to match the frame 2 and the exposure position.

[0048] In this case, the system 21; 22 further comprises a positioning unit 60 suitable for moving the support 50 bearing the processed substrate 1. As visible in these Figures, the positioning unit 60 comprises two moving stages 61, 62 along the two axes x, y adapted to move the support 50 (thus the processed substrate 1) respectively in the x and y directions. The positioning unit 60 is able to move the support from a distance higher than 300 millimeters in the y direction and a distance higher than 200 millimeters in the x direction.

[0049] In practice, the positioning unit 60 is adapted to move the processed substrate 1, step by step, from a frame 2 to another, corresponding here to a moving distance comprised between 20 and 36 millimeters in both directions.

[0050] The precision associated with the positioning unit 60 is lower than 5 micrometers, preferably lower than 1 micrometer.

[0051] According to Figures 5 and 6, the second alternative consists in moving the irradiation beam 105 (and thus the position of the corresponding micro-spot on the processed surface 5) instead of moving the processed substrate 1.

[0052] The system 23; 24 here comprises an overhead moving unit 45 suitable for moving the scanning unit 40 in order to move the position of the micro-spot of the irradiation beam 105 on the processed surface 5 of the processed substrate 1.

[0053] The overhead moving unit 45 comprises two moving parts 47, 48 adapted to move the scanning unit 40 respectively in the x and y directions. By moving the scanning unit 40 in the x or/and y directions, the overhead moving unit 45 thus allows moving the micro-spot of the irradiation beam 105 in the x and y directions in order to overlay the considered frame (i.e. the one to irradiate) of the processed surface 5 of the processed substrate 1.

[0054] The precision associated with the overhead moving unit 45 is lower than 5 micrometers, preferably lower than 1 micrometer.

[0055] In this configuration (with the overhead moving unit 45), the optical system 33 is thus able to adjust the modulated beam 101 at every moving step of the scanning unit 40.

[0056] As an alternative (not represented), the system can comprise both the positioning unit and the overhead moving unit, thus enabling moving respectively the support and the scanning unit. This alternative is particularly advantageous for very large processed substrates such as flat display panel with diameters higher than one meter.

[0057] As another alternative, the detection unit can be adapted to determine a rotation error. In this case, the support is able to rotate in order to compensate this error. The rotation movement is for example in the range of 2 degrees.

[0058] The system 21; 22; 23; 24 also comprises a control unit 90 which controls the interaction of the different parts of the system 21; 22; 23; 24. In particular, the control unit 90 synchronizes the different parts of the system 21; 22; 23; 24.

[0059] This control unit 90 includes a microprocessor and a memory. The memory stores instructions that allow the system 21; 22; 23; 24 to implement a method for uniformly irradiating the frame 2 of the processed substrate 1 as described below when these instructions are executed by the microprocessor.

[0060] Figure 7 shows an exemplary flowchart corresponding to the method for uniformly irradiating the frame of the processed substrate according to the invention.

[0061] As represented in Figure 7, this method comprises a step S2 of positioning the processed substrate 1 on the support 50. During this step S2 of positioning the processed substrate 1, the exact position of the processed substrate 1 is not known.

[0062] In order to uniformly irradiate each frame of the processed surface 5 of the processed substrate 1, the position of the processed substrate 1 needs to be determined.

[0063] The method thus comprises a step S4 of determining an initial position of the processed substrate 1. In practice, at step S4, the detecting unit 80 is adapted to detect one reference mark on the processed surface 5 of the processed substrate 1. Based on the detection of this reference mark, the control unit 90 is able to determine the initial position of the processed substrate 1.

[0064] As an alternative, if the processed surface does not comprise a reference mark, the position of the edges of the peripheral are 9 of the processed substrate 1 and particularly the position of the notch 8 can be used to determine the position of the processed substrate 1.

[0065] In practice, the detecting unit 80 evaluates a positioning unit by comparing the theoretical (expected) position of the reference mark and the detected one. This positioning error is then used by the control unit 90 to determine the initial position of the processed substrate 1.

[0066] At step S6, the control unit 90 then compares the detected initial position to an edge position. The edge position is localized in the peripheral area 9.

[0067] If the detected initial position does not correspond to an edge position, the step S8 is implemented leading to the irradiation of the processed surface 5 of the processed substrate 1. It is possible to assume here that, before the execution of the method according to the invention, the control unit 90 memorizes instructions in order to irradiate all the frames of the processed surface 5 of the processed substrate 1. These instructions for example comprise the order of the frames to irradiate. It is considered here that the previously named "to-be-irradiate frame" is for example the current frame to irradiate.

[0068] At step S8, the control unit 90 thus compares the detected initial position to a first predetermined position corresponding to the to-be-irradiated frame.

[0069] If the detected initial position matches with the first predetermined position, it means that the micro-spot of the irradiating beam 105 is directed to the considered frame (which is the first one to be irradiated in the stored instructions).

[0070] The method then comprises a step S10 of irradiating the considered frame by the irradiation beam 105. The irradiation beam 105 is controlled by the scanning unit 40 such that it irradiates uniformly the whole considered frame.

[0071] In practice and according to the present invention, the considered frame receives the transmitted energy whereas in the intermediate zone 7, the irradiation beam 105 is attenuated (meaning that the transmitted energy is lower than the one transmitted to the frame).

[0072] As an example, in the intermediate zone 7, the irradiation beam 105 is attenuated to more than 80% compared the irradiation beam 105 which covers the considered frame. Preferably, the irradiation beam 105 is completely attenuated in the intermediate zone 7.

[0073] As a consequence, the irradiation beam 105 is also attenuated in the surrounding frames of the considered irradiated frame (attenuation to more than 80% and preferably completely attenuated).

[0074] Advantageously according to the invention, the irradiation step is accurate and localized on the considered frame, thus allowing a uniform irradiation of this frame.

[0075] The method then continues with step S12 in which the control unit 90 determined if all frames has been irradiated. If it is the case, the processed substrate 1 is annealed. The control unit 90 sends (step S14) an instruction to remove the processed substrate 1 from the support 50 in order to complete the preparation of the processed substrate 1 and obtain final products.

[0076] If some frames have not been irradiated, as visible in Figure 7, the method comprises a step S16 of moving the micro-spot of the irradiation beam 105 from the first predetermined position to a second predetermined position associated with the following frame to irradiate (according to the order of irradiation of the stored instructions).

[0077] Two alternatives can be considered to move the micro-spot of the irradiation beam 105 in order to direct the irradiation beam to the frame associated with the second predetermined position.

[0078] The first solution is to move the support 50 bearing the processed substrate thanks to the positioning unit 60. The control unit 90 thus controls the positioning unit 60 in order to match the micro-spot of the irradiation beam with the second predetermined position.

[0079] The second solution is to directly move the position of the micro-spot of the irradiation beam 105 on the processed surface 5 of the processed substrate 1 by moving the scanning unit 40 thanks to the overhead moving unit 45. In this case, the control unit 90 controls the overhead moving unit 45 to move the scanning unit 40 in order to match the micro-spot of the irradiation beam with the second predetermined position.

[0080] When the step S16 is performed resulting in matching the micro-spot of the irradiation beam 105 with the second predetermined position on the processed surface 5 of the processed substrate 1, the method goes back to steps S10, S12, S14 and S16 as previously described.

[0081] If, at step S8, the detected initial position is different from the first predetermined position, this point means that the irradiation beam is not directed to the frame to irradiate according to the stored instructions. The method thus continues at step S20 of moving the micro-spot of the irradiation beam 105 in order to direct the irradiation beam 105 to the frame associated with the first predetermined position.

[0082] As previously described the two alternatives can be used here to match the micro-spot of the irradiation beam 105 with the first predetermined position.

[0083] When the step S20 is performed, the method continues with the step S10 of irradiating the considered frame and the following steps as represented in Figure 7.

[0084] If, at step S6, the detected initial position corresponds to an edge position, the control unit 90 controls the optical system 33 in order to attenuate or even block the irradiation of the processed surface 5 of the processed substrate 1 (step S30). In other words, the peripheral edge 9 is not directly irradiated by the irradiation beam 105.

[0085] As visible in Figure 7, the method continues with step S32 of determining if all the frames have been irradiated (step S32).

[0086] If it is the case, the processed substrate 1 is annealed. The control unit 90 sends (step S14 previously described) an instruction to remove the processed substrate 1 from the support 50 in order to complete the preparation of the processed substrate 1 and obtain final products.

[0087] If some frames have not been irradiated, the method continues at step S16.

[0088] Finally, this method stops when each frame of the processed surface 5 of the processed substrate has been uniformly irradiated. The control unit 90 is configured to implement this method on the whole processed surface 5 of the processed substrate 1, frame after frame, according to the stored instructions of irradiation.

Claims

1. Method for uniformly irradiating a frame (2) of a processed substrate (1), said processed substrate (1) comprising a plurality of frames (2), two consecutive frames (2) being separated by an intermediate zone (7),

   being **characterised in that** said method comprises the following steps:

   - determining an initial position of said processed substrate (1) using a detecting unit (80),
   - comparing said detected initial position with a first predetermined position associated with a first frame of the processed substrate (1),
   - irradiating said first frame of the processed substrate (1) by an irradiation beam (105) emitted by a source unit (30) and scanned by a scanning unit (40) based on the first predetermined position, said irradiation beam (105) being adapted to cover uniformly the whole first frame,

   an optical system (33) being configured such that the irradiation beam (105) is attenuated in the intermediate region (7).

2. Method according to claim 1, further comprising a step of moving said processed substrate (1) from said detected initial position to said first predetermined associated with the first frame of the processed substrate (1).

3. Method according to claim 1, further comprising a step of moving said scanning unit (40) based on the first predetermined position such that the irradiation beam (105) is directed to the first frame of the processed substrate (1).

4. Method according to any of claims 1 to 3, wherein the scanning unit (40) is configured such that the irradiation beam (105) is attenuated in the intermediate zone (7) to more than 80% compared to the irradiation beam (105) covering the first frame.

5. Method according to any of claims 1 to 4, wherein, the processed substrate (1) comprising at least one reference mark, said step of determining the initial position comprises a step of detecting said at least one reference mark on the processed substrate (1).

6. Method according to any of claims 1 to 4, wherein, the processed substrate (1) comprising edges of a peripheral area (9) and a notch (8), said step of determining the initial position comprises a step of detecting said edges of the peripheral area (9) and said notch (8) on the processed substrate (1).

7. Method according to any of claims 1 to 6, further comprising steps of:

   - moving the processed substrate (1) from the first predetermined position to a second predetermined position associated with a second frame of the processed substrate (1), said second frame being directly adjacent to said first

frame, and
- irradiating said second frame of the processed substrate (1) by the irradiation beam (105) emitted by the source unit (30) based on the second predetermined position, said irradiation beam (105) being adapted to cover uniformly the whole second frame.

8. Method according to any of claims 1 to 6, further comprising steps of:

- moving said scanning unit (40) based on a second predetermined position associated with a second frame of the processed substrate (1), said second frame being directly adjacent to said first frame, and
- irradiating said second frame of the processed substrate (1) by the irradiation beam (105) emitted by the source unit (30) based on the second predetermined position, said irradiation beam (105) being adapted to cover uniformly the whole second frame.

9. Method according to any of claims 1 to 8, wherein said step of detecting comprises a step of comparing said detected initial position to at least one edge position.

10. Method according to claim 9, also comprising a step of blocking the irradiation of the processed substrate (1) if the initial position corresponds to at least one edge position.

11. System (21; 22; 23; 24) for uniformly irradiating a frame (2) of a processed substrate (1), said processed substrate (1) comprising a plurality of frames (2), two consecutive frames (2) being separated by an intermediate zone (7), said system comprises (21; 22; 23; 24):

- a source unit (30) configured to emit an irradiation beam (105) towards processed surface (5) of the processed substrate (1),
- a support (50) designed to bear said processed substrate (1), and being **characterised by**:
- a detecting unit (80) configured to determine an initial position of said processed substrate (1),
- a control unit (90) configured to compare said detected initial position with a first predetermined position associated with a first frame of the processed substrate (1), and
- an scanning unit (40) configured to irradiate said first frame of the processed substrate (1) by emitting the irradiation beam (105), said irradiation beam (105) adapted to cover uniformly the whole first frame, and
- an optical system (33) which is configured such that the irradiation beam (105) is attenuated in the intermediate region (7).

12. System (21; 22) according to claim 11, further comprising a positioning unit (60) configured to move said processed substrate (1) from said detected initial position to a first predetermined position associated with a first frame of the processed substrate.

13. System (23; 24) according to claim 11, further comprising an overhead moving unit (45) adapted to move the scanning unit (40) based on the first predetermined position such that the irradiation beam (105) is directed to the first frame of the processed substrate (1).

14. System (21; 22; 23; 24) according to claim 11, wherein the optical system (33) is configured such that the irradiation beam (105) is attenuated to more than 80% in the intermediate zone (7) compared to the irradiation beam covering the first frame.

15. System (21; 22; 23; 24) according to any of claims 11 to 14, wherein an irradiation wavelength of the irradiation beam (105) is lower than 1064 nanometers, preferably equal to or lower than 355 nanometers.

16. System 21; 22; 23; 24) according to any of claims 11 to 15, wherein the source unit (30) comprises a laser source.

17. System (21; 22; 23; 24) according to any of claims 11 to 16, further comprising a vacuum chamber (70) housing the processed substrate (1) and the support (50).

Patentansprüche

1. Verfahren zur gleichmäßigen Bestrahlung eines Rahmens (2) eines verarbeiteten Substrats (1), wobei das verarbeitete Substrat (1) mehrere Rahmen (2) aufweist, wobei zwei aufeinanderfolgende Rahmen (2) durch eine Zwischenzone (7) getrennt sind,

dadurch gekennzeichnet, daß das Verfahren die folgenden Schritte aufweist:

- Bestimmen einer Ausgangsposition des verarbeiteten Substrats (1) unter Verwendung einer Erfassungseinheit (80),
- Vergleichen der erfaßten Ausgangsposition mit einer ersten vorbestimmten Position, die einem ersten Rahmen des verarbeiteten Substrats (1) zugeordnet ist,
- Bestrahlen des ersten Rahmens des verarbeiteten Substrats (1) mit einem Bestrah-

lungsstrahl (105), der von einer Quelleneinheit (30) ausgestrahlt wird und der von einer auf der ersten vorbestimmten Position befindlichen Abtasteinheit (40) abgelenkt wird, wobei der Bestrahlungsstrahl (105) so beschaffen ist, daß er den gesamten ersten Rahmen gleichmäßig abdeckt,

wobei ein optisches System (33) so ausgelegt ist, daß der Bestrahlungsstrahl (105) in der Zwischenzone (7) gedämpft wird.

2. Verfahren gemäß Anspruch 1, das außerdem einen Schritt des Bewegens des verarbeiteten Substrats (1) von der erfaßten Ausgangsposition zur vorbestimmten ersten Position aufweist, die dem ersten Rahmen des verarbeiteten Substrats (1) zugeordnet ist.

3. Verfahren gemäß Anspruch 1, das außerdem einen Schritt des Bewegens der in der ersten vorbestimmten Position befindlichen Abtasteinheit (40) derart aufweist, daß der Bestrahlungsstrahl (105) auf den ersten Rahmen des verarbeiteten Substrats (1) gerichtet wird.

4. Verfahren gemäß einem der Ansprüche 1 bis 3, wobei die Abtasteinheit (40) so ausgelegt ist, daß der Bestrahlungsstrahl (105) in der Zwischenzone (7) im Vergleich zum den ersten Rahmen abdeckenden Bestrahlungsstrahl um mehr als 80 % gedämpft wird.

5. Verfahren gemäß einem der Ansprüche 1 bis 4, wobei das verarbeitete Substrat (1) mindestens eine Bezugsmarkierung aufweist und der Schritt des Bestimmens der Ausgangsposition einen Schritt des Erfassens mindestens einer Bezugsmarkierung auf dem verarbeiteten Substrat (1) aufweist.

6. Verfahren gemäß einem der Ansprüche 1 bis 4, wobei das verarbeitete Substrat (1) Ränder eines peripheren Gebiets (9) und eine Einkerbung (8) aufweist und der Schritt des Bestimmens der Ausgangsposition einen Schritt des Erfassens der Ränder des peripheren Gebiets (9) und der Einkerbung (8) auf dem verarbeiteten Substrat (1) aufweist.

7. Verfahren gemäß einem der Ansprüche 1 bis 6, das außerdem Schritte des

- Bewegens des verarbeiteten Substrats (1) von der ersten vorbestimmten Position zu einer einem zweiten Rahmen zugeordneten zweiten vorbestimmten Position, wobei der zweite Rahmen direkt an den ersten Rahmen angrenzt, und
- Bestrahlens des zweiten Rahmens des verarbeiteten Substrats (1) mit dem von der in der zweiten vorbestimmten Position befindlichen Strahlungseinheit (30) ausgesandten Bestrahlungsstrahl (105), wobei der Bestrahlungsstrahl (105) so beschaffen ist, daß er den gesamten zweiten Rahmen gleichmäßig abdeckt, aufweist.

8. Verfahren gemäß einem der Ansprüche 1 bis 6, das außerdem Schritte des

- Bewegens der in einer einem zweiten Rahmen des verarbeiteten Substrats (1) zugeordneten zweiten vorbestimmten Position befindlichen Abtasteinheit (40), wobei der zweite Rahmen direkt an den ersten Rahmen angrenzt, und
- Bestrahlens des zweiten Rahmens des verarbeiteten Substrats (1) mit dem von der in der zweiten vorbestimmten Position befindlichen Strahlungseinheit (30) ausgesandten Bestrahlungsstrahl (105), wobei der Bestrahlungsstrahl (105) so beschaffen ist, daß er den gesamten zweiten Rahmen gleichmäßig abdeckt, aufweist.

9. Verfahren gemäß einem der Ansprüche 1 bis 8, wobei der Schritt des Erfassens einen Schritt des Vergleichens der erfaßten Ausgangsposition mit mindestens einer Position eines Rands aufweist.

10. Verfahren gemäß Anspruch 9, das auch einen Schritt des Blockierens der Bestrahlung des verarbeiteten Substrats (1), wenn die Ausgangsposition mindestens einer Position eines Rands entspricht, aufweist.

11. System (21; 22; 23; 24) zur gleichmäßigen Bestrahlung eines Rahmens (2) eines verarbeiteten Substrats (1), wobei das verarbeitete Substrat (1) mehrere Rahmen (2) aufweist, wobei zwei aufeinanderfolgende Rahmen (2) durch eine Zwischenzone (7) getrennt sind,
wobei das System (21; 22; 23; 24)

- eine Quelleneinheit (30), die dazu ausgelegt ist, einen Bestrahlungsstrahl (105) zur bearbeiteten Oberfläche (5) des verarbeiteten Substrats (1) auszustrahlen,
- einen Träger (50), der dazu ausgelegt ist, das verarbeitete Substrat (1) zu tragen, aufweist

und durch:

- eine Erfassungseinheit (80), die dazu ausgelegt ist, eine Ausgangsposition des verarbeiteten Substrats (1) zu bestimmen,
- eine Steuerungseinheit (90), die dazu ausgelegt ist, die erfaßte Ausgangsposition mit einer ersten vorbestimmten Position zu vergleichen, die einem ersten Rahmen des verarbeiteten

Substrats (1) zugeordnet ist,
- eine Abtasteinheit (40), die dazu ausgelegt ist, den ersten Rahmen des verarbeiteten Substrats (1) durch Ausstrahlen des Bestrahlungsstrahls (105) zu bestrahlen, wobei der Bestrahlungsstrahl (105) so beschaffen ist, daß er den gesamten ersten Rahmen gleichmäßig abdeckt, und
- ein optisches System (33), das so ausgelegt ist, daß der Bestrahlungsstrahl (105) in der Zwischenzone (7) gedämpft wird,

gekennzeichnet ist.

12. System (21; 22) gemäß Anspruch 11, das außerdem eine Positionierungseinheit (60) aufweist, die dazu ausgelegt ist, das verarbeitete Substrat (1) von der erfaßten Ausgangsposition zu einer ersten vorbestimmten Position zu bewegen, die einem ersten Rahmen des verarbeiteten Substrats zugeordnet ist.

13. System (21; 22) gemäß Anspruch 11, das außerdem eine Überkopfbewegungseinheit (45) aufweist, die dazu ausgelegt ist, die in der ersten vorbestimmten Position befindliche Abtasteinheit (40) so zu bewegen, daß der Bestrahlungsstrahl (105) auf den ersten Rahmen des verarbeiteten Substrats (1) gerichtet wird.

14. System (21; 22; 23; 24) gemäß Anspruch 11, wobei das optische System (33) so ausgelegt ist, daß der Bestrahlungsstrahl (105) in der Zwischenzone (7) im Vergleich zum den ersten Rahmen abdeckenden Bestrahlungsstrahl um mehr als 80 % gedämpft ist.

15. System (21; 22; 23; 24) gemäß einem der Ansprüche 11 bis 14, wobei die Bestrahlungswellenlänge des Bestrahlungsstrahls (105) kleiner als 1064 Nanometer, vorzugsweise kleiner als oder gleich 355 Nanometer ist.

16. System (21; 22; 23; 24) gemäß einem der Ansprüche 11 bis 15, wobei die Quelleneinheit (30) eine Laserquelle aufweist.

17. System (21; 22; 23; 24) gemäß einem der Ansprüche 11 bis 16, das außerdem eine Vakuumkammer (70) aufweist, in der das verarbeitete Substrat (1) und der Träger (50) untergebracht sind.

Revendications

1. Procédé pour irradier de façon homogène un cadre (2) d'un substrat (1) traité, le substrat (1) traité comprenant une pluralité de cadres (2), deux cadres successifs étant séparés par une zone intermédiaire (7),

étant **caractérisé en ce que** le procédé comprend les étapes suivantes :

- déterminer une position initiale du substrat (1) traité en utilisant une unité de détection (80),
- comparer la position initiale détectée à une première position prédéterminée associée à un premier cadre du substrat (1) traité,
- irradier le premier cadre du substrat (1) traité avec un faisceau d'irradiation (105) émis par une unité de source (30) et balayé par une unité de balayage (40) basée sur la première position, le faisceau d'irradiation (105) étant adapté pour couvrir uniformément le premier cadre entier,

un système optique (33) étant configuré de façon que le faisceau d'irradiation (105) soit atténué dans la zone intermédiaire (7).

2. Procédé selon la revendication 1, comprenant en outre une étape de déplacement du substrat (1) traité de la position initiale détectée à la première position prédéterminée associée au premier cadre du substrat (1) traité.

3. Procédé selon la revendication 1, comprenant en outre une étape de déplacement d'une unité de balayage (40) basée sur la première position prédéterminée de façon à ce que le faisceau d'irradiation (105) soit orienté vers le premier cadre du substrat (1) traité.

4. Procédé selon l'une quelconque des revendications 1 à 3, l'unité de balayage (40) étant configurée de manière telle que le faisceau d'irradiation (105) soit diminué de plus de 80% dans la zone intermédiaire (7) comparé au faisceau d'irradiation (105) couvrant le premier cadre.

5. Procédé selon l'une quelconque des revendications 1 à 4, le substrat (1) traité comprenant au moins un marquage de référence, l'étape de déterminer la position initiale comprend une étape de détecter au moins un marquage de référence sur le substrat (1) traité.

6. Procédé selon l'une quelconque des revendications 1 à 4, le substrat (1) traité comprenant des bords d'une zone périphérique (9) et une encoche (8), l'étape de déterminer la position initiale comprend une étape de détecter les bords de la zone périphérique (9) et l'encoche (8) sur le substrat (1) traité.

7. Procédé selon l'une quelconque des revendications 1 à 6, comprenant en outre les étapes de :

- déplacer le substrat (1) traité d'une première position prédéterminée à une seconde position prédéterminée associée à un second cadre du substrat (1) traité, le second cadre étant directement adjacent au premier cadre, et
- irradier le deuxième cadre du substrat (1) traité par le faisceau d'irradiation (105) émis par l'unité de source (30) basée sur la seconde position prédéterminée, le faisceau d'irradiation (105) étant configuré pour couvrir uniformément le second cadre entier.

8. Procédé selon l'une quelconque des revendications 1 à 6, comprenant en outre les étapes de :

- déplacer l'unité de balayage (40) basée sur une deuxième position prédéterminée associée à un deuxième cadre du substrat (1) traité, le deuxième cadre étant adjacent audit premier cadre, et
- irradier le deuxième cadre du substrat (1) traité par le faisceau d'irradiation (105) émis par l'unité de source (30) basée sur la deuxième position prédéterminée, le faisceau d'irradiation (105) étant configuré pour couvrir uniformément le deuxième cadre entier.

9. Procédé selon l'une quelconque des revendications 1 à 8, l'étape de détecter comprenant une étape de comparaison de la position initiale détectée à au moins une position du bord.

10. Procédé selon la revendication 9, comprenant aussi une étape pour bloquer l'irradiation du substrat (1) traité si la position initiale correspond à au moins une position du bord.

11. Système (21 ; 22 ; 23 ; 24) pour irradier de façon uniforme un cadre (2) d'un substrat (1) traité, deux cadres successifs étant séparés par une zone intermédiaire (7),

le système (21 ; 22 ; 23 ; 24) comprenant

- une unité de source (30) configurée pour émettre un faisceau d'irradiation (105) vers une surface (5) traitée du substrat (1) traité,
- un support (50) conçu pour porter ledit substrat (1) traité

et étant **caractérisé par** :

- une unité de détection (80) configurée pour déterminer une position initiale dudit substrat (1) traité,
- une unité de commande (90) configurée pour comparer ladite position initiale détectée à une première position prédéterminée associée au premier cadre du substrat (1) traité, et
- une unité de balayage (40) configurée pour irradier ledit premier cadre du substrat (1) traité en émettant le faisceau d'irradiation (105), le faisceau d'irradiation (105) étant configuré pour couvrir uniformément le premier cadre entier, et
- un système optique (33) qui est configuré de manière telle que le faisceau d'irradiation (105) soit atténué dans la zone intermédiaire (7).

12. Système (21 ; 22) selon la revendication 11, comprenant en outre une unité de positionnement (60) configurée pour déplacer le substrat (1) traité de ladite position initiale détectée vers une première position prédéterminée associée au premier cadre du substrat traité.

13. Système (23 ; 24) selon la revendication 11, comprenant en outre une unité de déplacement placée au-dessus et conçue pour déplacer l'unité de balayage (40) basée sur la première position prédéterminée, de façon à ce que le faisceau d'irradiation (105) soit dirigé vers le premier cadre du substrat (1) traité.

14. Système (21 ; 22 ; 23 ; 24) selon la revendication 11, le système optique (33) étant configuré de façon à ce que le faisceau d'irradiation (105) soit diminué de plus de 80% dans la zone intermédiaire (7) comparé au faisceau d'irradiation couvrant le premier cadre.

15. Système (21 ; 22 ; 23 ; 24) selon l'une quelconque des revendications 11 à 14, une longueur d'onde d'irradiation du faisceau d'irradiation (105) étant inférieure à 1064 nanomètres, de préférence égal ou inférieure à 355 nanomètres.

16. Système (21 ; 22 ; 23 ; 24) selon l'une quelconque des revendications 11 à 15, l'unité de source (30) comprenant une source laser.

17. Système (21 ; 22 ; 23 ; 24) selon l'une quelconque des revendications 11 à 16, comprenant en outre une chambre sous vide (70) abritant le substrat (1) traité et le support (50).

Fig.1

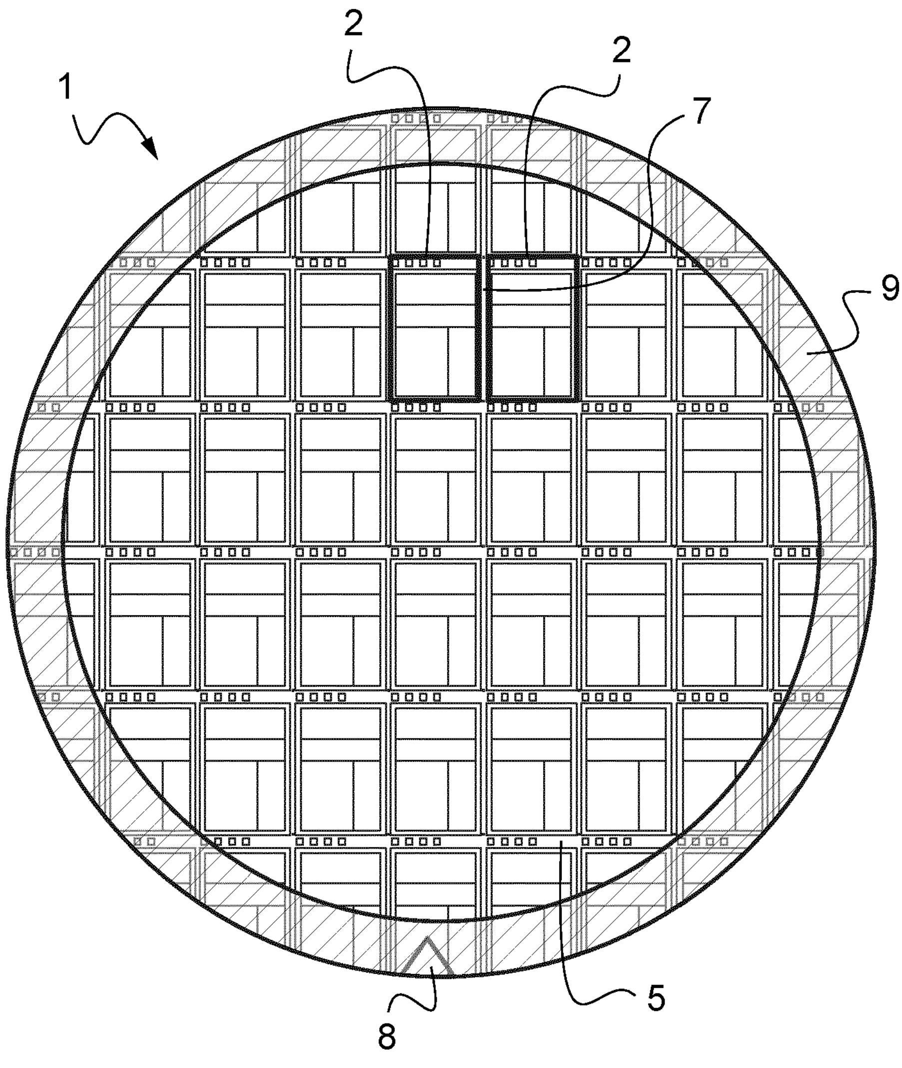
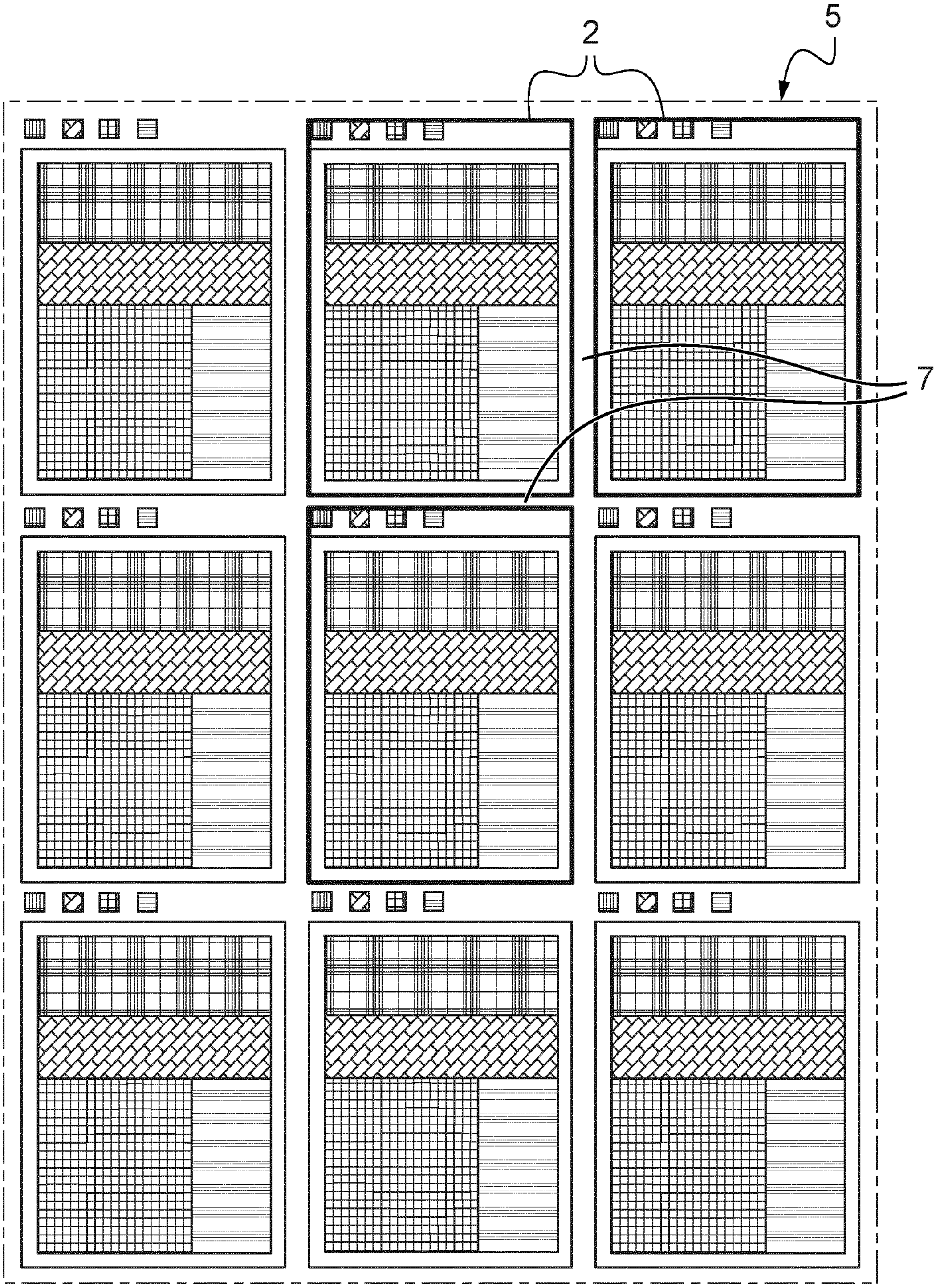


Fig.2



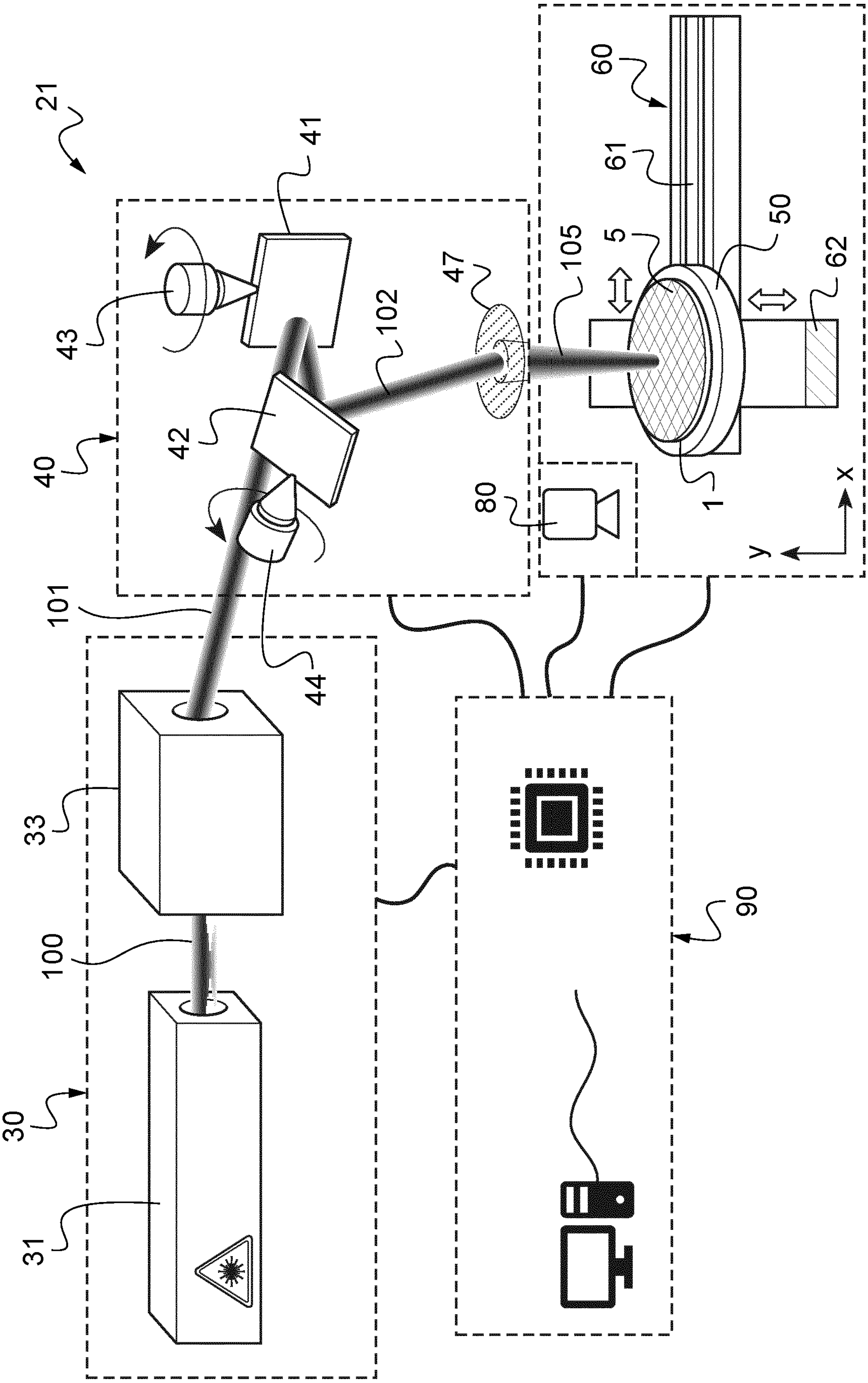
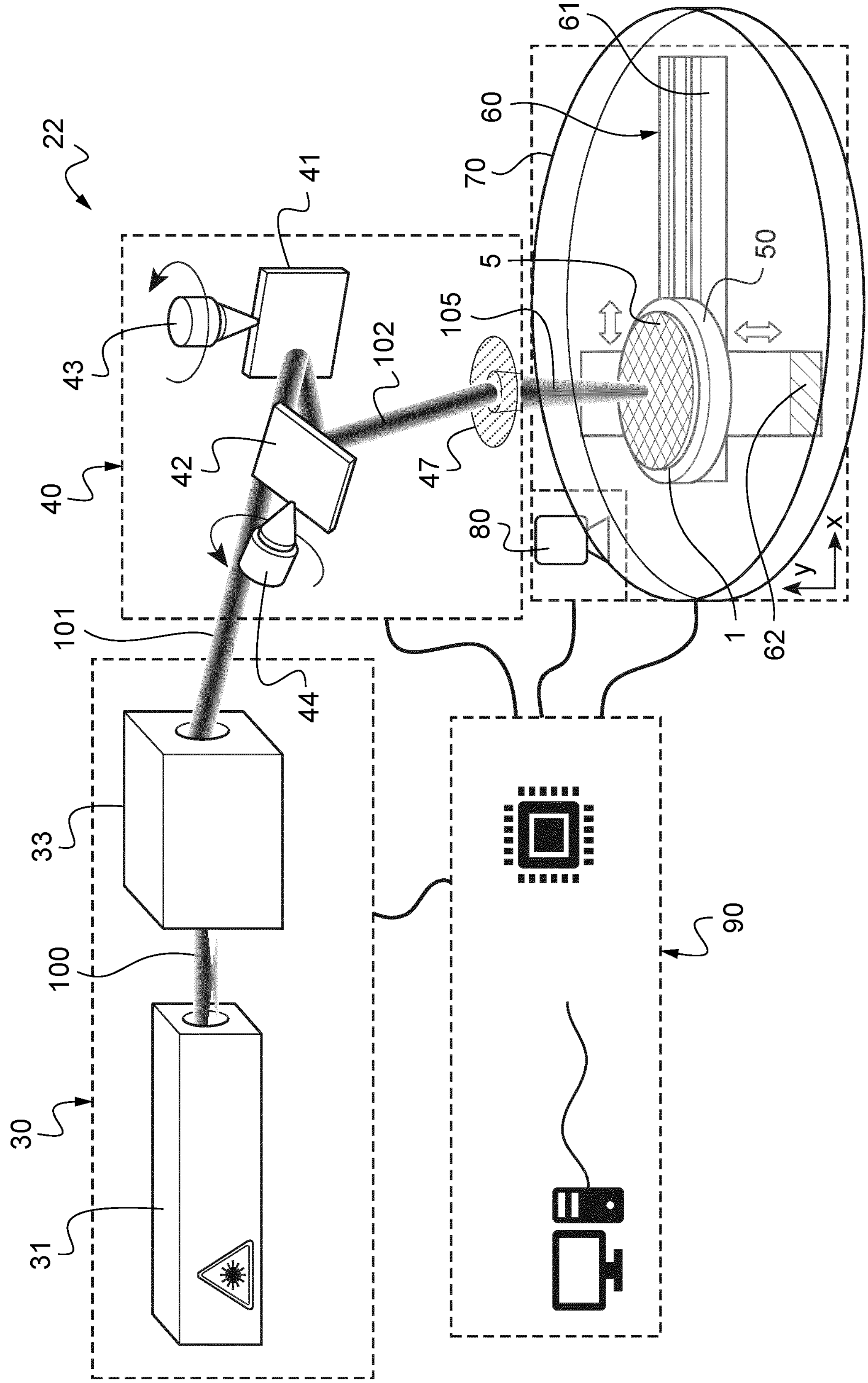


Fig.3

Fig.4


22
40
41
42
43
44
47
101
102
105
5
50
60
61
70
80
1
62
y
x
30
31
33
100
90

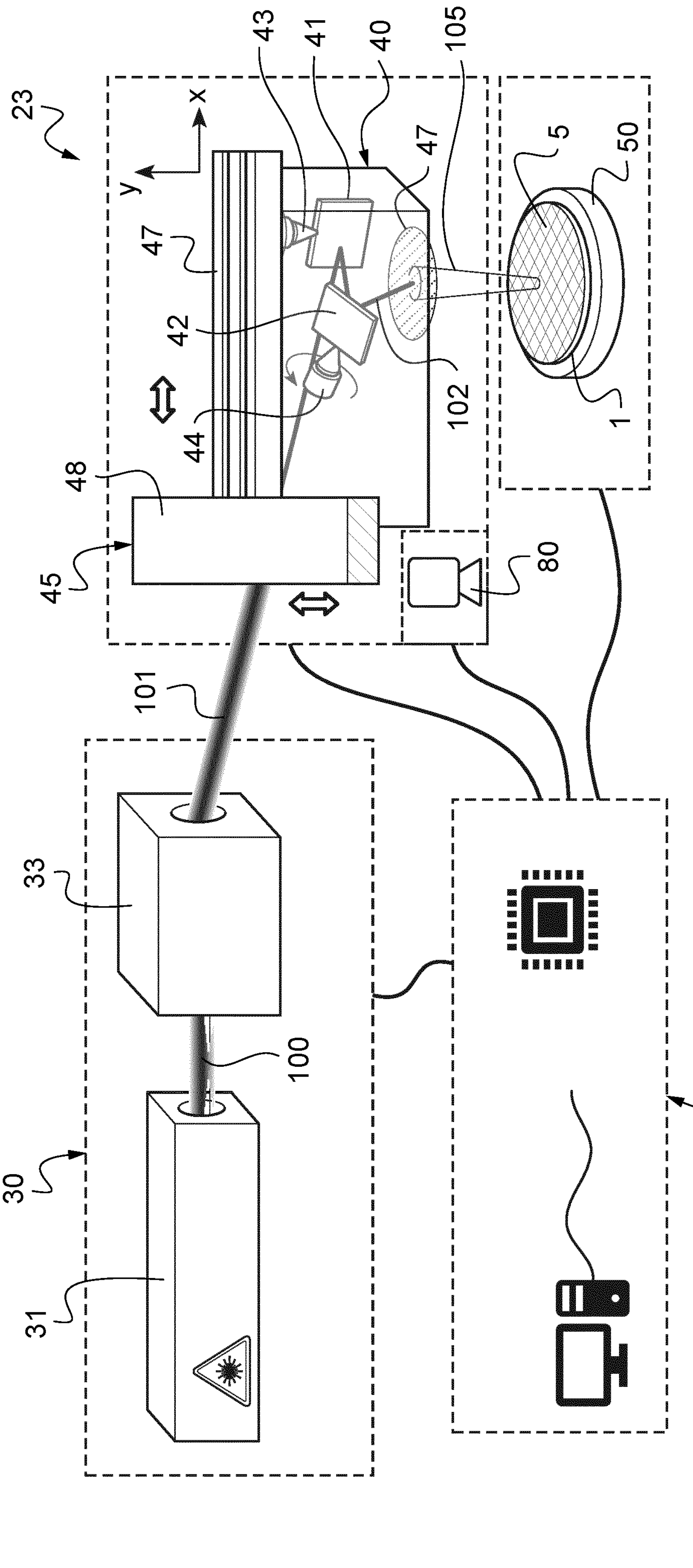


Fig.5

Fig.6

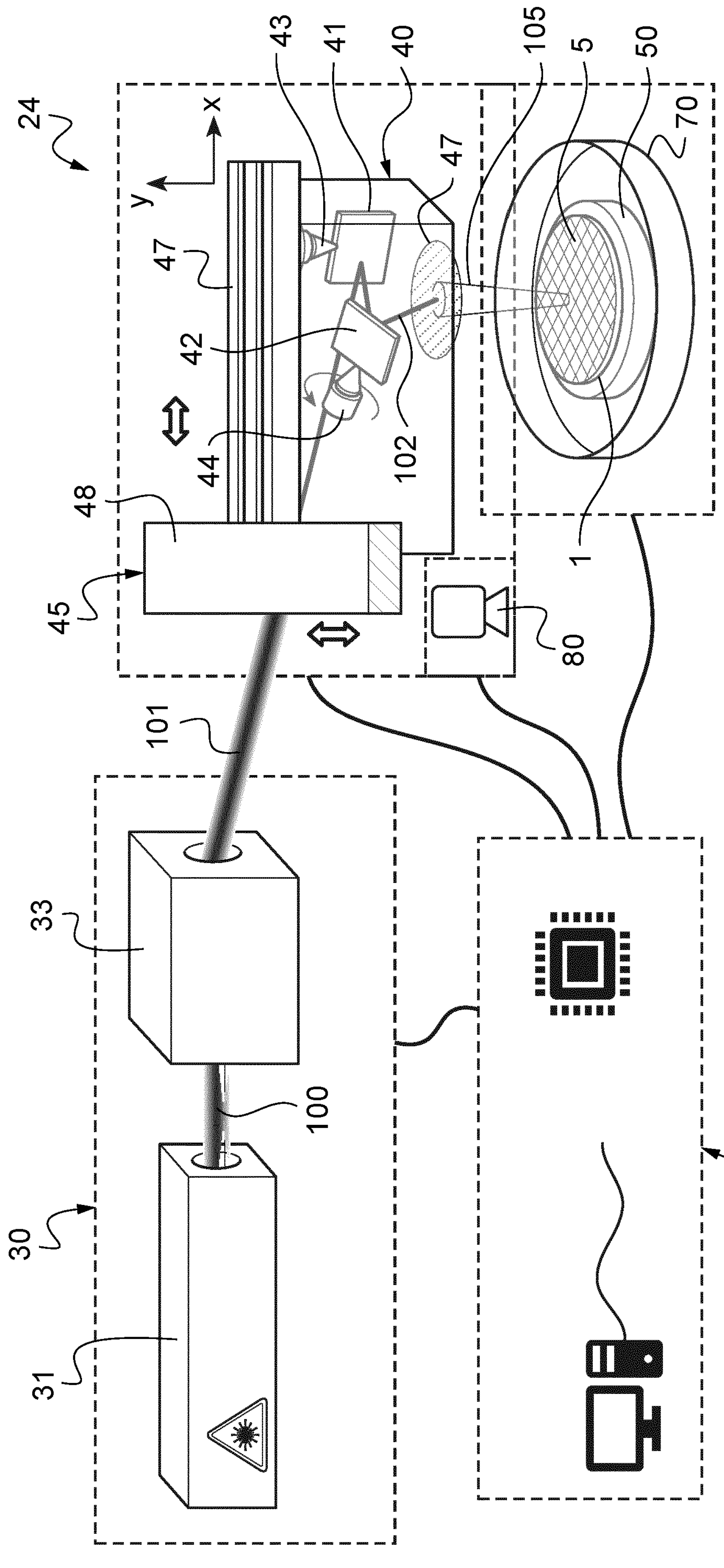
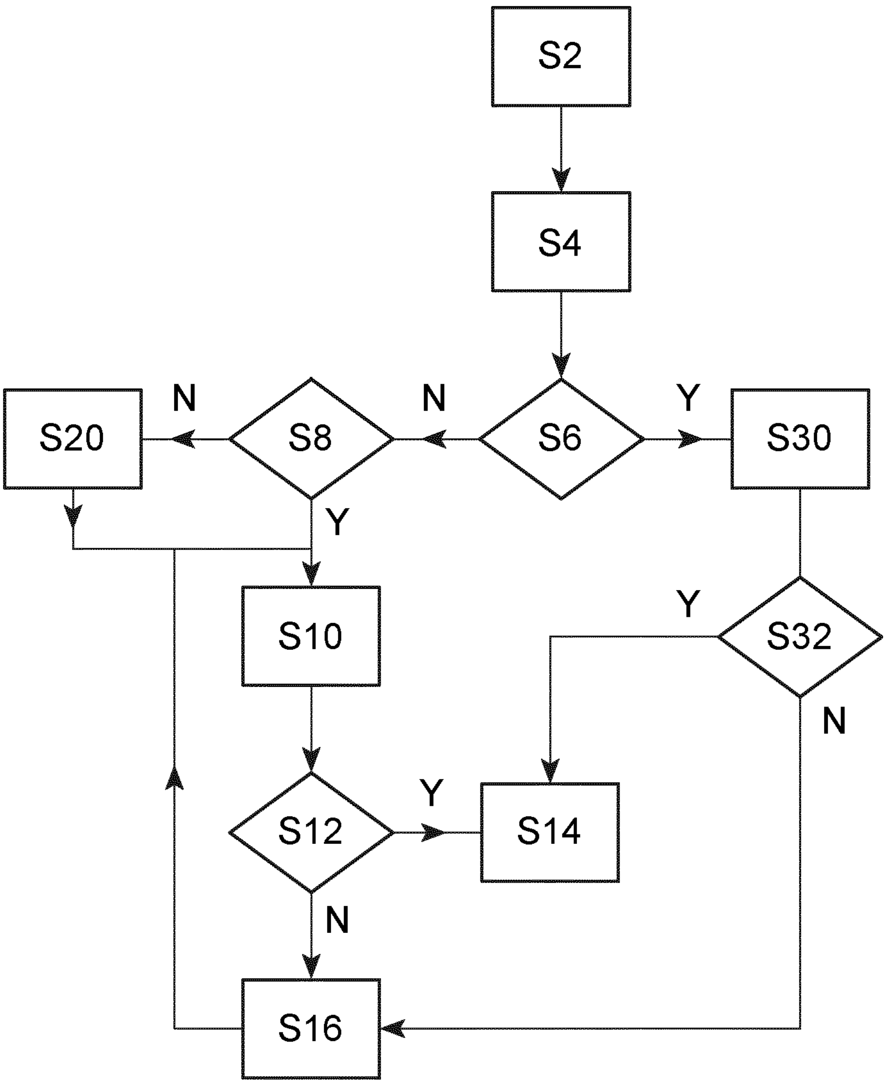

24
43
41
40
105
5
50
70
x
y
47
47
42
44
102
48
45
1
80
101
33
100
30
31
90

Fig.7



REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 2007024787 A1 **[0001]**